A Comparison of Mandibular Transverse Dimensions of a Class I Normal and Class II Patient Population using Anterior to Posterior Measurement Ratios

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A COMPARISON OF MANDIBULAR TRANSVERSE DIMENSIONS OF A CLASS I NORMAL AND CLASS II PATIENT POPULATION USING ANTERIOR TO POSTERIOR MEASUREMENT RATIOS

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DEDICATION

This thesis is dedicated to my children, who have had to live with me and without me through both school and work over the past 10 years. To my father and mother who convinced me that staying in school wasn't the prison sentence I was convinced it was in childhood. And to my wife, who has been my encouragement and motivation in my life since the day I met her.

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ABSTRACT

The transverse dimension of the craniofacial complex has long been suspected of following the deficiencies and excesses of the anteroposterior (AP) dimension. While the AP and even vertical dimensions of the maxilla and mandible have for years been easily assessed with the lateral cephalogram, the relative lack of posterior/anterior (PA) cephs in routine clinical use and a paucity of transverse analyses have made evaluation of the width of the mandible more subjective than the other dimensions. Since earlier analyses by Ricketts and Grummon evaluated the entire mandibular width measured only at the antegonial notch, the addition of more reliable landmarks in both the posterior and anterior mandible offers more information to analyze and a gives a better understanding of the mandible's taper from posterior to anterior. With reliable bilateral anterior and posterior landmarks, an anterior to posterior width ratio can be constructed to quickly assess the transverse dimension of the mandible.

This study's main objectives were, first, to identify bilateral landmarks in both the anterior and posterior mandible that could be reliably located using Cone Beam Computed Tomogaphy (CBCT) slices. Once these landmarks were determined in a Class I control population (n=49), a mean and standard deviation for the width at each landmark was determined and an AP width ratio was created. The second part of this study was to compare these data to the transverse measurements in a Class II population both at the individual landmarks and through the created width ratios. This should shed light on the long held notion that deficiencies identified in one plane often occur in all three planes of space. The most reliable landmarks identified in the anterior mandible were the canine root apices and the mental foramen, while the most reliable landmarks in the posterior were the alveolar ridge at the first molar and the lingula.

The results of the study demonstrated a statistically significant difference in transverse dimension between the Class I controls and class II subjects at the canine root apices. In the posterior mandible, the lingula (L) proved to be more reliable than the traditionally used antegonial notch (AG) for a skeletal landmark with interrater reliability of 0.845 for L vs. 1.83 for AG, though there was not a statistically significant difference between the class I and II subjects at either posterior landmark. Using the two most reliable landmarks in both the anterior and posterior mandible, four different width ratios were calculated.

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I. BACKGROUND AND LITERATURE REVIEW

A. Background

Transverse measurements of the craniofacial complex have received renewed interest in the field of orthodontics with the advent of 3-dimensional imaging capabilities (Cho 2009). Posterior-anterior (PA) cephalogram analysis, while not new to the field of orthodontics, often focuses on the identification of craniofacial asymmetries. (Quintero1999) Historically, mandibular transverse measurements played a minor role in the radiographic analysis of orthodontic patients with analyses such as Grummons' and Rickett's Rocky Mountain, using jugal point and antegonial notch mainly to relate the posterior mandible and maxilla (Grummons 1987, Ricketts 1981). Grummons used these points in combination with midline and lateral skeletal landmarks to identify asymmetry (Grummons 1987, 2004), while Ricketts used them to identify discrepancies between respective jaws comparing the ratios created to an age adjusted index (Ricketts 1981) or as reference points in creating lateral borders with which to judge jugal point in the maxilla. Both advanced the clinically useful information obtained from frontal cephalometric analysis working within the constraints of a traditional imaging.

Skeletal mandibular anterior landmarks have never been a part of a PA ceph analysis. While Grummons and Ricketts both incorporated the anterior dental landmark of the mandibular canine as the most reliable landmark with traditional PA cephalometry (El-Mangoury et al. 1987), their lack of anterior skeletal landmarks leaves the possibility of undiagnosed transverse discrepancies mesial to the antegonial notch. In addition, these analyses marked the incisal tip of the mandibular canine which incorporates error from ectopic eruption with variations in tip and torque and may not reflect the position of the housing dentoalveolar bone accurately. Thus, previous analysis of the mandibular transverse dimension through frontal imaging was never comprehensive.

The lack of additional mandibular landmarks may be due to the relative difficulty in treating transverse deficiencies or excesses within the lower jaw, which has fewer orthodontic and surgical options for intra-arch corrections. Instability of the mandible when expanded with removable appliances has been described by Schwarze (1972) with reports of relapse exceeding 50% at the canine. The maxilla, by contrast, is routinely expanded through surgical and or orthopedic forces to change its transverse dimensions differentially along the anteroposterior plane.

The formation and development of the mandible may shed some light on the relative difficulty in its expansion orthopedically. Early fusion of the mandible at the symphysis allows for significant interdigitation of the bone. Similar interdigitation of the midpalatal suture has been reported to increase the difficulty of obtaining skeletal expansion in the maxilla by various authors (Profitt 2007). With fusion of the two bones of the mandible occurring much earlier than in the maxilla, significant difficulty in achieving orthopedic expansion would be expected by the time transverse modification would typically be considered.

The nature of maxillary expansion, while controversial with regard to timing and appliance design among other aspects (Suri 2008), is better understood. True maxillary orthopedic expansion can be viewed at the midpalatal suture with the greatest amount occurring anteriorly and inferiorly (Profitt 4^{th} ed.). However, most clinicians appreciate the expansion needed and gained through study models and clinical impression, not obtaining a PA cephalogram to appreciate skeletal change.

Growth and mandibular transverse development is modified through the interplay of resorption and apposition. Changes in the width of the mandible occur largely through resorption on the infero-medial surfaces with deposition of bone on the lateral aspect of the mandible (Basavaraj 2011). This allows the mandible to widen as it extends sagittaly through deposition at the posterior ramus. While this may be appreciated through anthropological studies it is difficult to quantify these changes in the mandible particularly when there is currently only one landmark for transverse evaluation. Changes with adolescent growth of interdental widths also make this difficult to appreciate as they show little change beyond seven years of age (Lux 2004)

The justification for an additional radiograph to assess the transverse dimension with minimal diagnostic value left only 13% of orthodontists routinely using PA cephs (Gotlieb 1990) as compared to 69-82% for lateral cephs. (Gottlieb 1990). This disparity in use of PA radiographs when compared to lateral cephalograms can be explained by three specific barriers: 1) historical difficulties in handling differential magnification with traditional two-dimensional images, (Cho 2009) in combination with error arising from head orientation relative to the film (Quintero et al. 1999). 2) a shortage of accepted landmarks within the craniofacial region (Ricketts 1981) and 3) additional radiation dosage. All of these issues have hindered widespread use of mandibular transverse imaging and analysis. These barriers are undoubtedly interconnected, but most likely begin with the lack of accepted landmarks and the resulting lack of perceived benefit from additional imaging.

The attempt to analyze PA cephalograms has been complicated clinically by the varying distances of the structures from the film. The differential magnification created by the depth of the imaged head necessitates additional mathematical corrective measures, such as the method of similar triangles proposed by Wei and Adams (1963, 1970). Without adjustment using these protocols, the structures more distant from the film or sensor will appear larger and the distances separating two landmarks in that plane would appear greater than normal. This creates difficulties and adds complicated steps for clinicians that would use these images.

Use of the antegonial notch (or gonia) as the sole landmark with which to evaluate the width of the mandible fails to demonstrate transverse discrepancies at other points along the length of the mandible. This leaves mandibular width analysis defined by only two planes of space. In addition, problems are encoutered with the consistent location of the antegonial notch landmark which is subject to interpretation from different clinicians. If the landmark is placed significantly anterior or posterior due to the lack of a defined point along the curvature of the inferior border, the determined width would vary with the taper of the mandible and incorrectly estimate its width when compared to a maxillary skeletal landmark.

While some knowledge of the posterior aspect of the lower jaw is obtained in this way, the 3-dimensional mandible is left completely without quantification of the anterior aspect where the majority of the teeth lie (Ricketts 1981). Transverse deficiencies or excesses in the mandible may be undiagnosed since the tools for measurement have never been fully used or even developed. Identifying discrepancies along the length of the mandible could provide the clinician with information to impact treatment decisions and ultimately open new possibilities in treatment modalities. Incorporating anterior landmarks in the transverse analysis of a 2D image, however, is complicated by overlap of structures and limited research of norms for this area. Imaging techniques have changed rapidly over the past decade and provide new opportunities for investigation of the craniofacial complex in all dimensions. The growing prevalence of these advanced imaging techniques offers the opportunity to quantify the measures cephalometrically and develop norms to add to anteroposterior and vertical measures and norms (Cho 2009).

Treatment of transverse deficiencies within the mandible has been attempted for quite some time. McNamara, in his text (2001) and others have advocated the use of a removable expansion device, such as the Schwartz appliance, in an attempt to correct occlusal relationships and increase space available within the dental arch. Claims of true skeletal expansion with this or other appliances have met great skepticism with various authors citing over-expansion of the mandibular arch leading to relapse of intercanine width on long term follow-up (Tulley et al 1960,Schwarze 1972). Both Schwarze and Brust (1992) report significant relapse following mandibular intercanine expansion. One explanation for this relates to the lack of an immature suture within the corpus of the mandible to split with orthopedic force. Without a split of the body of the mandible the dentoalveolar segments are left as the point of least resistance. This leads to buccal tipping of the mandiblular teeth with an increased possibility for relapse if the buccal segments were initially upright or buccaly inclined. Other studies did; however, find that the mandibular intercanine width might be slightly expanded when maxillary expansion accompanied this change (Haas 1961, 1965, Sandstrom 1988) as well as when a pre-existing Class II div 2 dental relationship exists (Shapiro 1974).

Distraction osteogenesis (DO) has received increasing attention in the medical and orthodontic fields within the last ten years. This technique requires a surgical split at the symphysis followed by slow expansion, which allows hard and soft tissue adaptation, thus increasing the range of possible movements as well as decreasing the amount of expected relapse. DO, as described by Ilizarov (DO reference) in the 1950s, increases long bone length through slow and continuous movement of two segments of bone away from each other following a controlled and stabilized fracture. The potential advantage when considering transverse changes in the mandible is the opportunity for adaptation of the soft tissues within the temporomandibular joint. Gunbay (2009) reported well tolerated expansion of the mandible and no lasting dysfunction of the temporomandibular joint with a bone born distractor achieving a mean of 6.48mm of expansion. With this much potential for change in the mandibular transverse dimension, guidelines outside of dental measures could prove helpful. Mandibular transverse ideals need to be identified so that the clinician may know the end point in treating with expansion or constriction.

Historically, many assessments examining both pre- and post-treatment analysis of transverse changes were accomplished through study models and dial type calipers or more recently digitally scanned models. Several of these studies evaluated pre-treatment factors that influenced post-retention stability (Kahl-Nieke et al. 1996, Suri 2008). Notably, increased initial constriction of the intermolar and intercanine widths as well as severe crowding were included as an indicators for increased incidences of relapse post-expansion (Kahl-Nieke et al. 1996). That is, the greater the anomaly pre-treatment, the greater the tendency toward relapse post-treatment. However, measurements made from dental casts may allow only inferences about the skeletal relationships and their changes. Increases in arch width with treatment and decreases in arch width post-treatment are assessed only through the dental relationships.

These types of measurements are a convenient approach to assessing the changes in tooth position, both absolute width and inclination. However, skeletal changes cannot be measured directly from this information. The problem with relying on dental measurements in determining transverse information is they leave the skeletal changes underreported or unreliable. Madjidi et al. (2009) described a method for evaluating transverse changes within the mandible following mandibular narrowing that removed the reliance on axial inclinations of the teeth or the need for additional radiographic exposure. Using semitransparent occlusal tracings of the mandibular dentition marked with a sagittal, posterior and angular line, overlays of different time points allowed measurement of the angular changes from anterior to posterior. This method also accounted for the sagittal changes seen from rotation about the symphseal osteotomy which could easily go unnoticed. While the Madjidi method removes the error from dental movement, similar to other dental evaluations, the measurements cannot differentiate between skeketal and dental alterations.

Mandibular deficiency in the antero/posterior dimension may have been recognized from the earliest times and quantified since the advent of the lateral cepholagram. The lateral ceph and its measures have guided orthodontic analysis and treatment of class II skeletal discrepancies since the middle of the 20th century. While a concomitant transverse deficiency in those patients presenting with an anterior/posterior deficiency has been suspected, it has been difficult to document through skeletal measures and analyses. Recent research with computed tomography examining patients with hemifacial microsomia for example has shown corresponding volumetric deficiencies even of the unaffected hemimandible. (Steinbacher et. al 2011). This is suggestive of the three dimensional nature of mandibular hypoplasia, and demonstrates the need for a fresh look at mandibular transverse analysis.

The volumetric studies required a more sophisticated model and view of the imaged structures. The ability to isolate areas of interest in three dimensions creates an opportunity to view skeletal structures without the need for surgical exposure or estimations from two dimensional images. With cone beam computed tomography, CBCT, the number of barriers to transverse analysis is significantly reduced and it potentially provides a better platform to construct the measurements for analysis of mandibular transverse deficiencies or excesses.

CBCT has emerged from the culmination of years of refinement of the scanning technologies initially developed for medical use. Its immediate forerunner, the conventional CT, suffered from many negatives, making it difficult to justify its use in dentistry. Beyond the cost to the provider to obtain a machine or, more likely, the necessity to source out the imaging, the large amount of radiation required and the time needed to capture the image hindered its adoption by dental professionals. The improved image produced by these medical grade CT scanners is undeniable. Incorporating the third dimension in records acquisition permits an evaluation of the depth of the image where overlapping structures can be segmented separately and viewed individually.

Far from a scaled down version of the conventional CT, CBCT represents an improvement for head and neck imaging in many ways over the third generation conventional CTs most commonly seen in medical use today (Sukovic 2004). CBCT devices emit a conical array of beams which are captured on two dimensional scanners. This conical beam of electrons increases the captured amount of information from one rotation about the subject. Movement artifact and radiation exposure can be minimized without the need for expensive fast moving pieces necessary to accelerate image acquisition in conventional CTs designed for the whole body (Sukovic 2004). This is possible because the larger two dimensional detector obviates the need for multiple slices (ie. exposures) that must then be stacked to create three dimensional images. Thus, the image can be obtained faster and with minimal motion artifact which enhances image quality while decreasing radiation exposure.

The emergence of 3-D imaging into orthodontics has removed the need for an additional image to be acquired for transverse analysis. While concerns remain relating to the potential increase in exposure when comparing lateral cephalograms to cone beam CTs, it is important to note that additional information, like the frontal ceph equivalent, is made available to the practitioner. With increased interest in reducing patient exposure to radiation, this is indeed a large step forward in increasing demand for, and usage of, a transverse analysis. The method of acquisition and reconstruction of the CBCT eliminates the differential magnification that complicated the two dimensional image analysis and current machines offer various modes to reduce radiation exposure (Durack 2011). This may involve more focused or smaller viewing areas or settings that adjust the resolution so that adequate analysis doesn't require overexposure. Incorporating copper filtration would also reduce exposure when using CBCT and has been shown to reduce radiation exposure by >40% (Ludlow 2011). The ability to remove fore- and background clutter through slices simplifies the location of many points and eliminates the need for shift shot techniques or multiple exposures for location of points of interest (Bernardes et al 2012). Current scanners have a range of possible exposure settings and resultant radiation exposure. However, the majority of scans used for orthodontics expose the patient to between 30 – 80 μSv, for whole head images as compared to the roughly 24μSv required for a digital panoramic and lateral cephalogram (Miracle 2009). These exposure amounts also do not incorporate an additional PA cephalogram or various anterior periapical films for adult patients which can help when evaluating the initial periodontal status.

CBCT offers a larger data set from each acquired image. Image acquisition occurs through a process that produces a three dimensional image from one rotation about the subject with computer software algorithms that build the image from voxels (the volumetric base image unit) (Cevidanes 2006). These renderings can be viewed and manipulated in three dimensions to quickly assess the patient. Images can also be sliced at any point in the coronal, sagital, or axial planes eliminating the overlap that complicates traditional or digital two dimensional PA films (Quintero 1999). These slices offer undistorted information and images at any point along the mandible which allows true three dimensional evaluation rather than a scan of the computer generated renderings (Berco 2009, Periago 2008). However, use of the information obtained from CBCT requires complex software to manipulate the data into a more intuitive format for clinical use (Cevidanes 2006, De Oliveira 2009). The computing power necessary to manipulate the data generated from these type of scanners has only recently been available at costs that allow for easy incorporation into smaller medical or dental practices (Sukovic 2004). Cheaper memory and faster processors made the migration into routine dental practice a reality and have provided valuable insight in implant dentistry and orthodontics in particular.

Moreover, the wealth of information obtained from a single scan makes it possible to fully evaluate a patient in three dimensions using comprehensive imaging for comprehensive orthodontics.

Our research aims to establish reliable anterior and posterior landmarks for the mandible in an initial pilot study which provides a basis for construction of a width ratio for the mandible of a normal class I patient population. Once Class I normal ratios are identified, a separate Class II population, due to mandibular deficiency, were evaluated. The AP width ratio measures were then compared against the norms from the Class I population to determine if a mandibular transverse deficiency in the class II population accompanies the AP deficiency.

II. OBJECTIVES

A. Overall Objective

The purpose of this study was to first identify reliable landmarks within the mandible for a Class I sample, then utilize these landmarks to create anteroposterior width ratios. During this initial or pilot study, both posterior and anterior landmarks were evaluated in a Class I control group. This enabled the creation of an anteroposterior (A-P) width differential for a Class I population in the main focus of the study. A Class II sample due to mandibular A-P deficiency was then identified and an AP width differential created for comparison to the Class I group.

B. Specific Hypotheses

There is no difference in mandibular transverse measurements between Class I and Class II patients due to anteroposterior hypoplasia of the mandible.

III. MATERIALS AND METHODS

PART 1- Class I subjects

This retrospective study included patients who were evaluated at the Tri-Service Orthodontic Residency Program with pretreatment CBCTs on file, taken on Classic i-CAT machines (Imaging Sciences International, Hatfield, PA). After a search of the program's Dolphin Management database, 49 subjects were selected based on inclusion criteria to comprise the Class I normal group. These met the following criteria:

1. Be at least 14 years old for female or 16 years old for male subjects
2. Skeletal Class I with bilateral Class I molars and canines, with an ANB of 2°-5°.
3. Non-ectopic canines (no impactions)
4. No crossbites or transverse dental compensations (as diagnosed by the treating resident/staff doctor)
5. Have mandibular plane value (SN-MP) less than 38 degrees
6. Have less than 8mm crowding.

A faculty member not associated with the study then approved all study patients from the Tri Service Orthodontic Residency Program (TORP) archived patient database. Patient name, age, and any other personal information were de-identified. Each patient's CBCT was then identified by "MAN-I" and an identification number "1-49", and resaved in the patient database for the examiner to view. The examiner oriented and saved each radiograph in simulated natural head position, with Frankfort horizontal parallel to the floor and the line connecting midpoints of Christa Galli (CG) and Anterior Nasal Spine (ANS) perpendicular to the floor. All landmarks were labeled using the Dolphin 3D software application (Dolphin Imaging, and Management, Chatsworth, CA) and measured in the transverse plane. The investigator utilized measurement tools in Dolphin Imaging Software, (Dolphin Imaging Software, California) and after measuring at three separate time points, these values were averaged and standard deviation derived.

As a pilot study, the first 20 images were used to measure bilateral landmarks. Three anterior and four posterior landmarks in the mandible were identified by one investigator directly on slices made from these pre-existing CBCTs. The landmarks identified are shown in Figures 1 and 2 and described below:

Anterior bilateral landmarks identified are: 1. Mental foramena (MF) 2. Canine root apex (CA) 3. Anterior alveolar ridge (AvRCa) measured at the greatest alveolar convexity below the canine. Posterior bilateral landmarks are: 1. Antegonial notches (AN) 2. Lingula (L) 3. Intermolar width at mandibular first molar (central fossa of the mandibular first molars or Man 6) 4. Alveolar ridge at mandibular first molar (AvRM) at the greatest alveolar convexity below the mesial buccal cusp of the first molar.

All landmarks were labeled using the Dolphin 3D software application (Dolphin Imaging, and Management, Chatsworth, CA) and measured in the transverse plane on the initial 20 images. Measurement tools of Dolphin Imaging Software (Dolphin Imaging Software, California) were utilized. Landmarks were located and resulting widths measured three times separated by one week between each timepoint, and averaged by the one examiner. Standard deviations were also determined. The examiner then identified the landmarks providing the best ease of location and with the most consistent reproducibility before beginning Part II of the study. (Table 1)

Table 1. **Seven different width measurements for Class I patients (used for initial 20 Class I patients). Concordance determined through the calculation of interclass correlation coefficients and their 95% confidence interval**

Widths	Measurement 1	Measurement 2	Measurement 3	Mean	Standard Deviation
MF-MF					
CA-CA					
AvRCa-AvRCa					
AN-AN					
Man 6-Man 6					
L-L					
AvRM-AvRM					

After the most reliable anterior and posterior transverse landmarks were identified, Part 2 of the study was initiated.

PART 2- The remaining 29 Class I normal subjects were evaluated at the points identified from the pilot study and combined with the 20 pilot study subjects to determine the anterior to posterior width ratio in the Class I normal group. Once completed evaluation of the Class II patients was initiated.

Class II subjects were selected based on the inclusion criteria for the Class II group due to mandibular A-P deficiency which included:

1. Be at least 14 years old for female, and 16 years old for male subjects.
2. Skeletal Class II with bilateral Class II molars and ANB ≥ 5°.
3. No ectopic canines (no impactions)
4. No crossbites or transverse dental compensations (as diagnosed by the treating resident/staff doctor).
5. Have a mandibular plane value (SN-MP) lower than 38°.
6. Less than 8mm crowding in either arch

CBCTs were reviewed, landmarks identified, mean widths and standard deviations noted, these were identified by “MAN II” followed by an identification number “1-30”. Anterior and posterior width ratios were determined based on the landmarks identified in Part I. A summary of possible calculated ratios to be measured in the study is summarized in Table 2. Based on the results of the pilot study and a desire to incorporate both skeletal and dental landmarks, two anterior and two posterior locations were chosen and the final ratios summarized in Table 3. This, in turn, will allow comparison of the anterior to posterior width ratios of the Class I normal and the Class II mandibular deficient groups.

Table 2. **Anterior:posterior width ratios evaluated, pilot study**

		POSTERIOR			
		AN	L	Man 6	AvRM
ANTERIOR	MF	RATIO	RATIO	RATIO	RATIO
	CA	RATIO	RATIO	RATIO	RATIO
	AvRCa	RATIO	RATIO	RATIO	RATIO

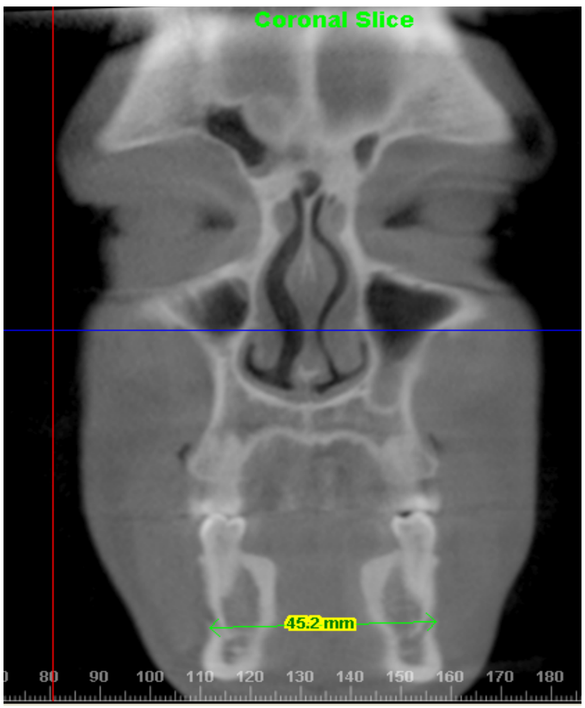
Table 3: Anterior:posterior actual width ratios generated

	POSTERIOR				
		AvRM	L		
ANTERIOR	MF	RATIO	RATIO		
	CA	RATIO	RATIO		

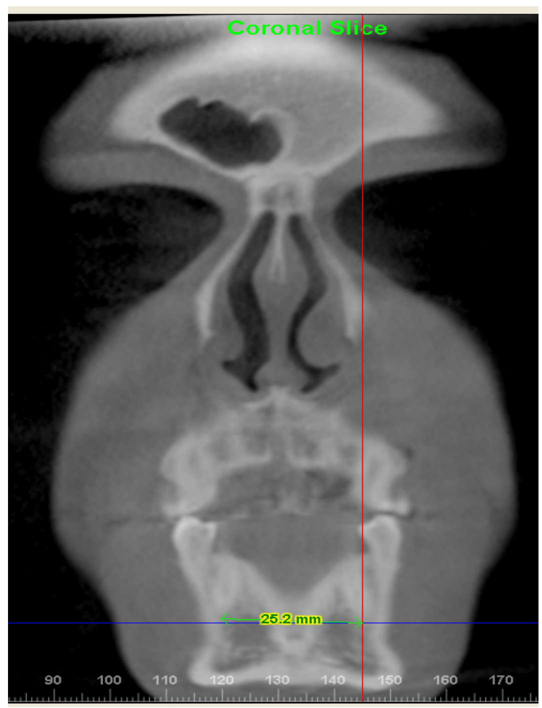
Fig. 1: CBCT slices of anterior landmarks

Anterior Landmarks: 1. Mental Foramen (MF), 2. Canine Apex (CA) 3. Anterior Alveolar Ridge at Canine (AvRCA).

MF-MF



CA-CA



AvRCA-AvRCA

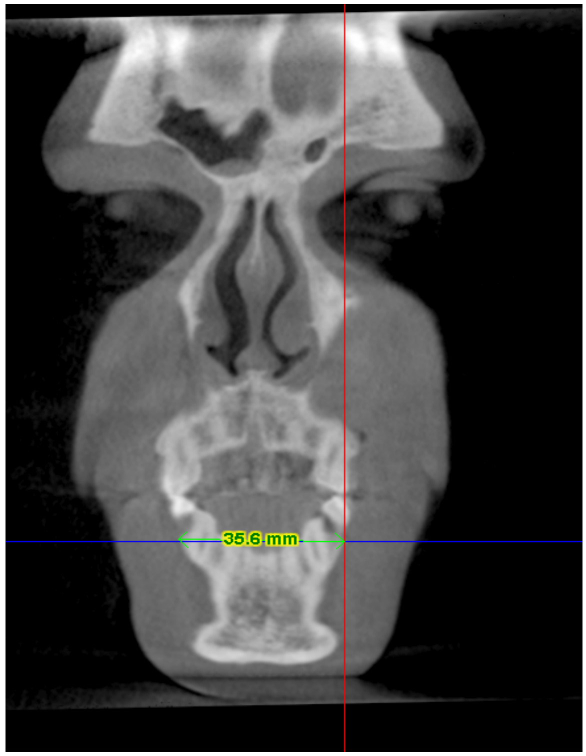
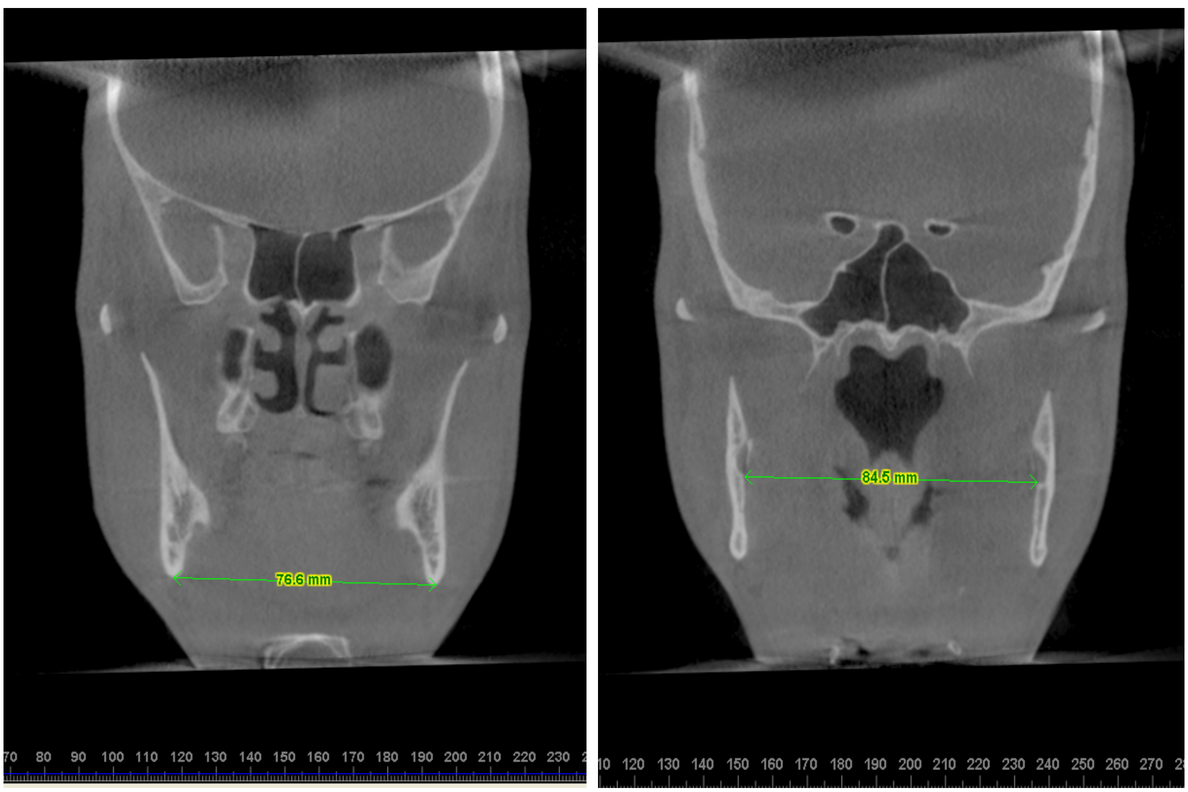


Fig. 2: CBCT slices of posterior landmarks

Posterior Landmarks: 1. Antegonial Notch (AN), 2. Lingula (L) 3. Alveolar Ridge at Mesial Buccal Cusp of First Molar (AvRM) 4. Central Fossa of Mandibular First Molar (Man 6)

AN-AN **L-L**



AvRM-AvRM

Man 6- Man6

IV. RESULTS

Table 4: Pilot study landmark identification and intra-rater correlation

PILOT STUDY - CLASS I PATIENTS (1-20 OF 49)				
		Raw Average	Std Dev of means	Intrarater reliability (avg std dev/pt)
ANTERIOR	MF-MF	49.90821	2.495265	0.705593
	CA-CA	20.29833	2.995971	0.730941
	AvRCA-AvRCA	28.95667	2.756069	0.886714
POSTERIOR	AN-AN	81.04545	4.794471	1.826352
	L-L	78.02917	3.390514	0.844762
	AvRM-AvRM	51.7	3.071535	0.441906
	Man6-Man6	41.32333	3.099615	0.551425

In Table 4 the pilot study results are categorized. The general location and individual landmarks are listed in the first two columns. From the twenty Class I subjects evaluated in the pilot study, the means of the transverse measurements are listed in column three with their standard deviation in column four. The fifth column represents the statistic evaluated to deduce intra-rater reliability. Since each landmark was located at three different time points, the mean of the standard deviations was used as an indicator of reproducibility.

Table 5: Class I transverse measurements

CLASS I PATIENTS (n=49)				
		Raw Average	Std Dev of mean	Avg st dev/pt
ANTERIOR	CA-CA	20.23	2.682	0.598
	MF-MF	46.82	3.04	0.706
POSTERIOR	AvRM-AvRM	52.68	2.51	0.414
	L-L	78.67	4.45	0.547

Table 5 displays the data accumulated once the landmarks deemed to have the lowest reproducibility in the pilot study were excluded. Here again the means, standard deviations and intra-rater reliability are displayed in the third, forth, and fifth column respectively. While some of the reproducibility figures varied from those in the pilot study every landmark had less variability.

Figure 3: Class I mandibular transverse measurement box plot

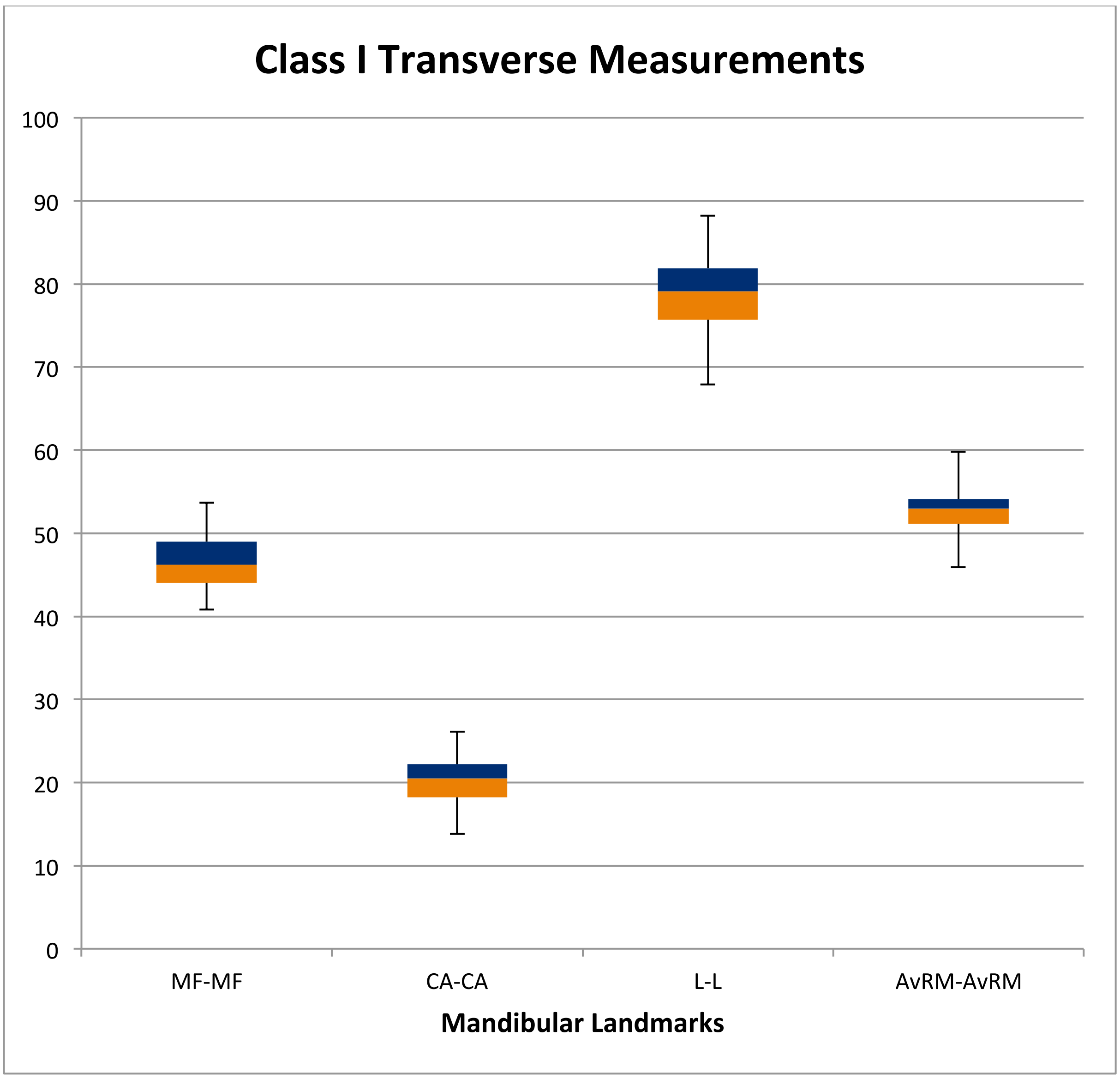


Figure 3 above demonstrates the distribution of the data in quartiles about the median for each landmark. The midline or color break for each block represents the median with the lower block representing the 1st quartile and the upper block representing the 3rd quartile of values. The lines extending beyond the colored boxes identify the maximum and minimum values for each measurement.

Table 6: Class II transverse measurements

CLASS II PATIENTS (n=30)				
		Raw Average	Std Dev	Intrarater reliability (avg std dev/pt)
ANTERIOR	CA-CA	18.01	2.19	0.366035036
	MF-MF	45.83	2.59	0.358668458
POSTERIOR	AvRM-AvRM	51.7	3.14	0.269364922
	L-L	76.84	3.64	0.331660755

Similar to the table 5 above, table 6 displays the data collected for the Class II subjects. Again, the third, fourth, and fifth columns list the means, standard deviations, and intra-rater reliabililty. The intra-rater reliability values once again showed improvements over the pilot study.

Figure 4: Class II mandibular transverse measurement box plot

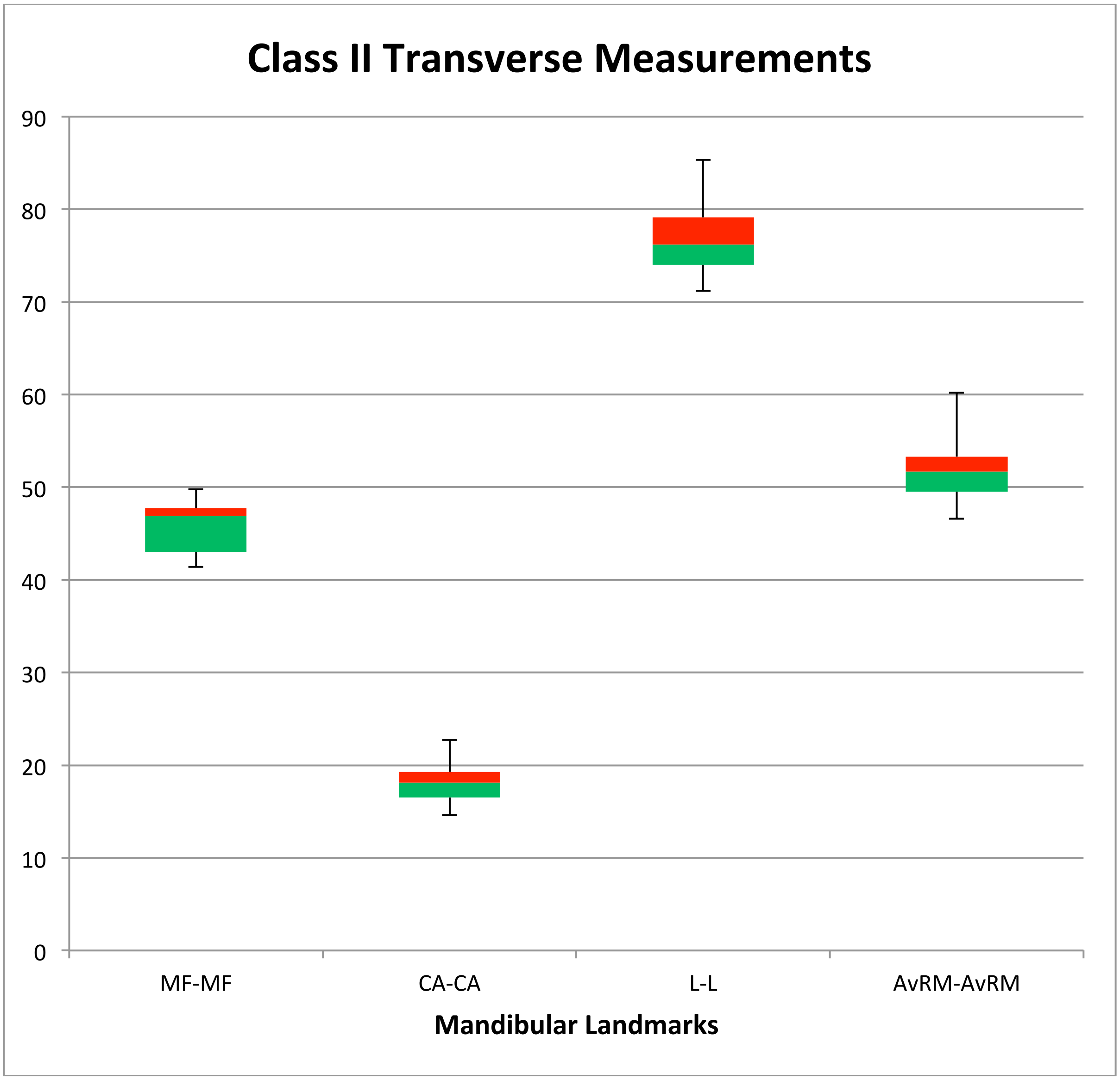
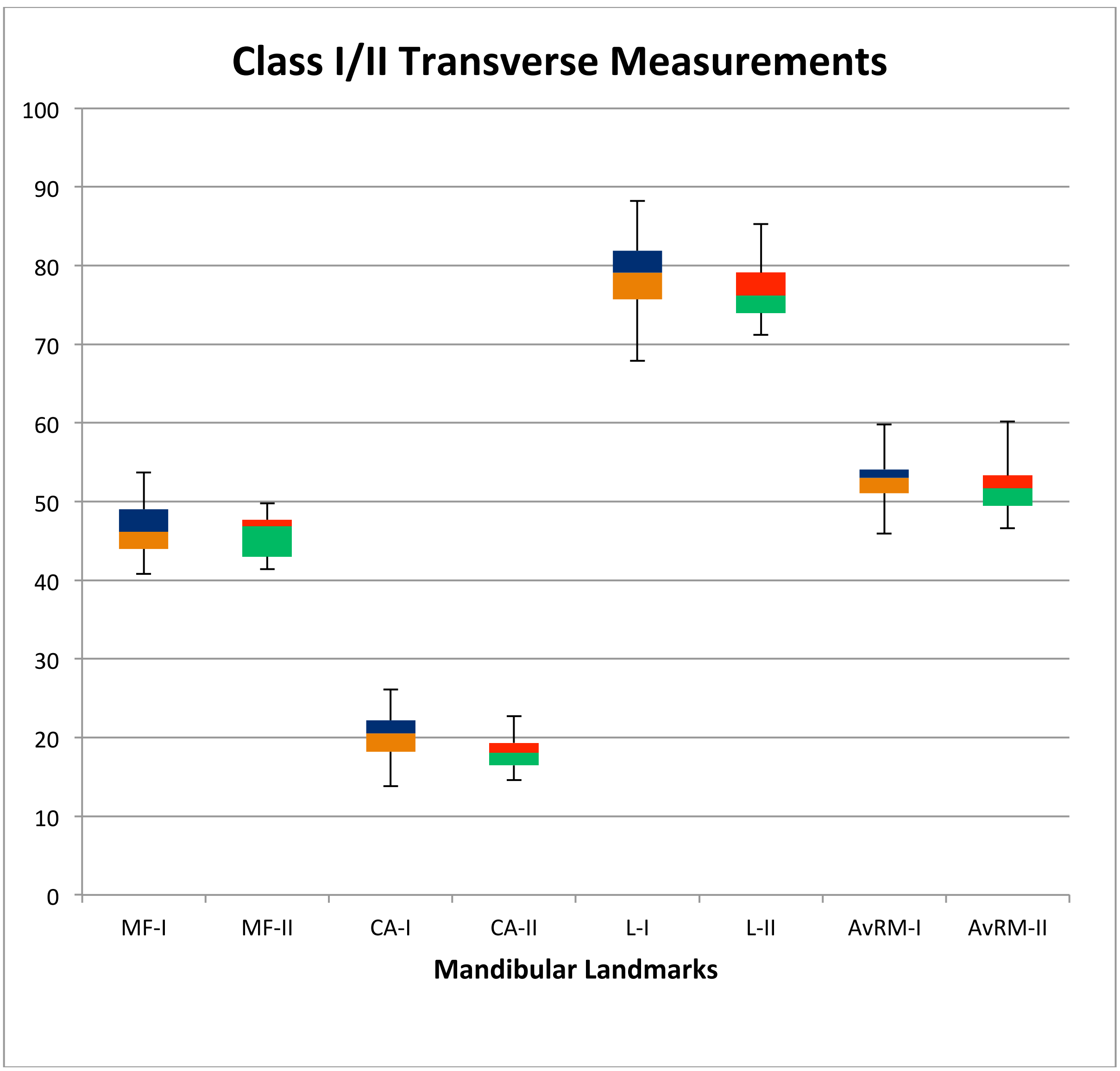


Figure 4 above demonstrates the distribution of the data in quartiles about the median for each landmark in the class II group. The midline or color break for each block represents the median with the lower block representing the 1st quartile and the upper block representing the 3rd quartile of values. The lines extending beyond the colored boxes identify the maximum and minimum values for each measurement.

Figure 5: Class I/II mandibular transverse measurement box plot



In Figure 5 above the distribution of the data from the Class I and Class II subjects are placed together for easier comparison of the medians and quartiles. The T test values included at the end of the results section verify that only the canine apex demonstrated a statistically significant difference between Class I and Class II subjects (P=.0003) among the landmarks analyzed.

Table 7: Class I anterior:posterior width ratio

Anterior to Posterior Width ratios				
		Raw Average	Std Dev	
ANTERIOR	MF-LL	0.601423	0.040283	
	MF-AvRM	0.889766	0.055678	
POSTERIOR	CA-LL	0.257651	0.034128	
	CA-AvRM	0.383987	0.04723	

Combining the anterior and posterior landmarks to create a ratio of the anterior to posterior transverse dimensions provided the data charted in Tables 7 and 8. The means were obtained from all 49 class I subjects in Table 7 and all 30 subjects in Table 8 with standard deviations included. A skeletal (mental foramen to lingual, MF-LL) and dental (canine apex to alveolar ridge at the 1st molar, CA-AvRM) ratio were constructed. Combined skeletal and dental ratios were also established to complete the data in Tables 7 and 8.

Table 8: Class II anterior:posterior width ratio

Anterior to Posterior Width ratios				
		Raw Average	Std Dev	
ANTERIOR	MF-LL	0.597442	0.039699	
	MF-AvRM	0.888493	0.059006	
POSTERIOR	CA-LL	0.234872	0.030154	
	CA-AvRM	0.349614	0.047362	

Comparing the Class I with the Class II subjects ratios revealed a statistically significant difference (P=..0024) in the dental ratio (CA-AvRM on pg 37). This also revealed a statistically significant difference (P=.0036) in the combined skeletal/dental ratio (CA-LL on pg 37) involving the canine apex. Neither the established skeletal ratio (MF-LL) nor the combined skeletal/dental ratio (MF-AvRM) provided a statistically significant difference between the two groups with P values of .9029 and .09234 respectively.

-- landmark=AVRM --

The TTEST Procedure

Variable: AVGMEAS (AVGMEAS)

Class	N	Mean	Std Dev	Std Err	Minimum	Maximum
1	49	52.6796	2.5118	0.3588	46.1333	59.6000
2	30	51.7000	3.1440	0.5740	46.6333	60.1667
Diff (1-2)		0.9796	2.7669	0.6414		

Class	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
1		52.6796	51.9581	53.4011	2.5118	2.0946	3.1380
2		51.7000	50.5260	52.8740	3.1440	2.5039	4.2266
Diff (1-2)	Pooled	0.9796	-0.2977	2.2568	2.7669	2.3905	3.2851
Diff (1-2)	Satterthwaite	0.9796	-0.3792	2.3384			

Method	Variances	DF	t Value	Pr > |t|
Pooled	Equal	77	1.53	0.1308
Satterthwaite	Unequal	51.355	1.45	0.1540

Equality of Variances

Method	Num DF	Den DF	F Value	Pr > F
Folded F	29	48	1.57	0.1651

-- landmark=CA-CA --

The TTEST Procedure

Variable: AVGMEAS (AVGMEAS)

Class	N	Mean	Std Dev	Std Err	Minimum	Maximum
1	49	20.2286	2.6825	0.3832	13.8000	26.1000
2	30	18.0133	2.1860	0.3991	14.6333	22.7000
Diff (1-2)		2.2152	2.5071	0.5812		

Class	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
1		20.2286	19.4581	20.9991	2.6825	2.2370	3.3513
2		18.0133	17.1971	18.8296	2.1860	1.7409	2.9386
Diff (1-2)	Pooled	2.2152	1.0579	3.3725	2.5071	2.1660	2.9766
Diff (1-2)	Satterthwaite	2.2152	1.1119	3.3185			

Method	Variances	DF	t Value	Pr > |t|
Pooled	Equal	77	3.81	0.0003
Satterthwaite	Unequal	70.777	4.00	0.0002

Equality of Variances

Method	Num DF	Den DF	F Value	Pr > F
Folded F	48	29	1.51	0.2415

-- landmark=L-L --

The TTEST Procedure

Variable: AVGMEAS (AVGMEAS)

Class	N	Mean	Std Dev	Std Err	Minimum	Maximum
1	49	78.6701	4.4596	0.6371	67.5333	88.2333
2	30	76.8367	3.6436	0.6652	71.2333	85.3333
Diff (1-2)		1.8334	4.1711	0.9669		

Class	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
1		78.6701	77.3891	79.9510	4.4596	3.7190	5.5714
2		76.8367	75.4761	78.1972	3.6436	2.9018	4.8981
Diff (1-2)	Pooled	1.8334	-0.0920	3.7588	4.1711	3.6036	4.9523
Diff (1-2)	Satterthwaite	1.8334	-0.00334	3.6701			

Method	Variances	DF	t Value	Pr > |t|
Pooled	Equal	77	1.90	0.0617
Satterthwaite	Unequal	70.674	1.99	0.0504

Equality of Variances

Method	Num DF	Den DF	F Value	Pr > F
Folded F	48	29	1.50	0.2475

-- landmark=MF-MF --

The TTEST Procedure

Variable: AVGMEAS (AVGMEAS)

Class	N	Mean	Std Dev	Std Err	Minimum	Maximum
1	49	46.8252	3.0391	0.4342	40.8333	53.7000
2	30	45.8300	2.5926	0.4733	41.3667	49.8333
Diff (1-2)		0.9952	2.8791	0.6674		

Class	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
1		46.8252	45.9522	47.6981	3.0391	2.5344	3.7968
2		45.8300	44.8619	46.7981	2.5926	2.0648	3.4853
Diff (1-2)	Pooled	0.9952	-0.3339	2.3242	2.8791	2.4874	3.4183
Diff (1-2)	Satterthwaite	0.9952	-0.2862	2.2766			

Method	Variances	DF	t Value	Pr > |t|
Pooled	Equal	77	1.49	0.1400
Satterthwaite	Unequal	68.87	1.55	0.1259

Equality of Variances

Method	Num DF	Den DF	F Value	Pr > F
Folded F	48	29	1.37	0.3641

The TTEST Procedure

Variable: CA_AVRM (CA/AVRM)

Class	N	Mean	Std Dev	Std Err	Minimum	Maximum
1	49	0.3840	0.0472	0.00675	0.2692	0.4869
2	30	0.3496	0.0474	0.00865	0.2837	0.4389
Diff (1-2)		0.0344	0.0473	0.0110		

Class	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
1		0.3840	0.3704	0.3976	0.0472	0.0394	0.0590
2		0.3496	0.3319	0.3673	0.0474	0.0377	0.0637
Diff (1-2)	Pooled	0.0344	0.0125	0.0562	0.0473	0.0408	0.0561
Diff (1-2)	Satterthwaite	0.0344	0.0124	0.0563			

Method	Variances	DF	t Value	Pr > |t|
Pooled	Equal	77	3.14	0.0024
Satterthwaite	Unequal	61.328	3.13	0.0026

Equality of Variances

Method	Num DF	Den DF	F Value	Pr > F
Folded F	29	48	1.01	0.9648

Variable: CA_LL (CA/LL)

Class	N	Mean	Std Dev	Std Err	Minimum	Maximum
1	49	0.2577	0.0341	0.00488	0.1730	0.3218
2	30	0.2349	0.0302	0.00551	0.1841	0.2926
Diff (1-2)		0.0228	0.0327	0.00758		

Class	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
1		0.2577	0.2478	0.2675	0.0341	0.0285	0.0426
2		0.2349	0.2236	0.2461	0.0302	0.0240	0.0405
Diff (1-2)	Pooled	0.0228	0.00769	0.0379	0.0327	0.0282	0.0388
Diff (1-2)	Satterthwaite	0.0228	0.00810	0.0375			

Method	Variances	DF	t Value	Pr > |t|
Pooled	Equal	77	3.01	0.0036
Satterthwaite	Unequal	67.311	3.10	0.0028

The TTEST Procedure

Variable: CA_LL (CA/LL)

Equality of Variances

Method	Num DF	Den DF	F Value	Pr > F
Folded F	48	29	1.28	0.4816

Variable: MF_AVRM (MF/AVRM)

Class	N	Mean	Std Dev	Std Err	Minimum	Maximum
1	49	0.8898	0.0557	0.00795	0.7698	1.0100
2	30	0.8885	0.0590	0.0108	0.7742	1.0286
Diff (1-2)		0.00127	0.0570	0.0132		

Class	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
1		0.8898	0.8738	0.9058	0.0557	0.0464	0.0696
2		0.8885	0.8665	0.9105	0.0590	0.0470	0.0793
Diff (1-2)	Pooled	0.00127	-0.0250	0.0276	0.0570	0.0492	0.0676
Diff (1-2)	Satterthwaite	0.00127	-0.0255	0.0281			

Method	Variances	DF	t Value	Pr > |t|
Pooled	Equal	77	0.10	0.9234
Satterthwaite	Unequal	58.697	0.10	0.9246

Equality of Variances

Method	Num DF	Den DF	F Value	Pr > F
Folded F	29	48	1.12	0.7070

Variable: MF_LL (MF/LL)

Class	N	Mean	Std Dev	Std Err	Minimum	Maximum
1	49	0.5963	0.0403	0.00575	0.5016	0.6776
2	30	0.5974	0.0397	0.00725	0.5141	0.6734
Diff (1-2)		-0.00114	0.0401	0.00929		

The TTEST Procedure

Variable: MF_LL (MF/LL)

Class	Method	Mean	95% CL Mean		Std Dev	95% CL Std Dev	
1		0.5963	0.5847	0.6079	0.0403	0.0336	0.0503
2		0.5974	0.5826	0.6123	0.0397	0.0316	0.0534
Diff (1-2)	Pooled	-0.00114	-0.0196	0.0174	0.0401	0.0346	0.0476
Diff (1-2)	Satterthwaite	-0.00114	-0.0196	0.0174			

Method	Variances	DF	t Value	Pr > |t|
Pooled	Equal	77	-0.12	0.9029
Satterthwaite	Unequal	62.162	-0.12	0.9026

Equality of Variances

Method	Num DF	Den DF	F Value	Pr > F
Folded F	48	29	1.03	0.9524

V. DISCUSSION

This study first demonstrated that there are anterior and posterior landmarks in the mandible that are more consistently located through coronal and axial CBCT slices than the antegonial notch. Both a skeletal and dental landmark in the anterior and posterior were chosen following the pilot study to assess the width of the mandible. In the anterior the mental foramen and canine apices were selected (with intrarater reliability measurements of 0.70 and 0.73 respectively) while in the posterior the lingula and alveolar ridge at the mesial buccal cusp of the first molar were selected based on the intra-rater reliability assessment (with intra-rater reliability measurements of 0.84 and 0.44 respectively) and an desire to include skeletal components both anteriorly and posteriorly.

Mental foramen, had the best intra-rater reliability scores of the all anterior landmarks chosen. It is a point that could prove difficult to locate in traditional PA cephalograms due to overlap of other mandibular structures, However as a point of initial ossification as the mandible develops lateral to Meckel's cartilage in utero, it should prove relatively stable during growth and development. With CBCT, this important structure is much more easily located and provides information not often utilized to assess the width of the anterior mandible. Beyond simple location, evaluating this and other landmarks within the craniofacial complex with CBCT, the true distance between two points may be measured since sagittal asymmetries are accounted for.

Antegonial notch, in the posterior, proved difficult to locate in three dimensions, due to the continuous curve of gonia in many patients along the inferior border of the mandible. With two dimensional PA cephalograms antegonial notch could be localized essentially along the curve of one line. Adding depth to the image made localization difficult due to the thickness of the inferior border and the additional curve this created. This may help to explain the intra-rater reliability scores that it received when compared to the other posterior landmarks in this study.

The individual transverse measurements were statistically compared using Student's T-test for samples with normal distribution. Once these were compared ratios were calculated combing anterior and posterior transverse measurements. These ratios were then compared, once again utilizing Student's T-test for samples with a normal distribution to determine if a difference exists in the mandibular transverse dimension between Class I and Class II populations.

The findings of this study demonstrated that Class II patients had statistically significant differences in transverse measurements at the canine root apices when compared with Class I normal subjects (18.0, 20.2mm respectively). This contrasts somewhat with findings of other investigators who found only slight differences in intercanine width within the mandible among different malocclusions and more significant differences in the premolar and molar regions (Sayin, Uysal and Kuntz, Huth) However, class III patients exhibited a wider alveolar width while Class II patients exhibited a narrower width than a class I normal population according to Slaj (Slaj et al. 2010). In this study, the transverse measures at mental foramen, lingula and the molar alveolar ridge measured in the second half of the study demonstrated smaller values for class II patients when compared with Class I, though they were not found to be statistically significant. This would lend some merit to the assumption that there is a corresponding transverse deficiency in patients with mandibular AP hypoplasia. However, the lack of an absolute difference outside of the canine apices certainly hints at the limited information provided by the transverse measurement at gonia that has been used in previous analysis. With Ricketts and Grummons analysis, where only the antegonial notch was used; differences between the Class I and Class II populations might have been hidden by either the poor reproducibility noted in the pilot study or the lack of a significant difference between the populations in the posterior mandible.

There are difficulties when basing an analysis of the width of the mandible on non-skeletal structures. Teeth may be malposed in individuals and do not have to reflect the width of the skeletal structures they are housed in. It is important to note that teeth are not the only landmarks presenting with such anomalies or variance in location. The mental foramen is a skeletal landmark yet varies in its relative AP and veritical position in the jaw, with either dimension potentially affecting the resulting transverse difference (Hasan 2011).

The use of canine apex in the transverse analysis incorporates the possibility of bias with tooth position. While canine apex is not a skeletal landmark, it is a focal point which lends itself to easier identification in comparison with a point located along a longer curved surface, such as antegonial notch. This might explain the relatively low scores it received in intra-rater readings as compared to the mental foramen and the alveolar ridge at mid canine, which had intra-rater reliability scores of .73, .70 and .88 repectively. Also, the significant difference noticed between groups (mean intercanine distance of 20.2mm for the class I sample and 18.0mm for the Class II sample with $P<.05$) carries additional weight with a landmark that is proven easier to identify. Significantly displaced or impacted canines were excluded from the samples to increase the reliable placement of the canine within the dentoalveolar bone.

The presence of a significant difference between the transverse measures at canine apex would lead one to suspect a difference between groups when this measurement is included in the construction of a ratio. The combination of canine apex with either posterior landmark yielded ratios with a statistically significant difference between the Class I and Class II groups. Canine apex compared with the alveolar ridge at the mandibular 1st molar (CA: AvRM) and canine apex compared to the Lingula (CA:LL) both had $P<.05$ ($P=.0024$, and $P=.0036$ respectively). Mental foramen however, failed to create a statistically significant difference when combined with either anterior landmark (MF:AvRM $P=.9234$, MF-LL $P=.9029$). Thus the canine apices were selected as the anterior reference in construction of the anteroposterior width ratio.

The process of selecting the posterior landmark for inclusion in the AP width ratio required first, evaluation of the most reliable landmark from the pilot study (Alveolar ridge at first mandibular molar with a .44 intra-rater reliability score was the most reproducible point in the posterior or anterior mandible). In combination with Lingula, this satisfied our original aim of identifying a skeletal landmark to assess mandibular width. It was concluded that the wide variation found in posterior landmark identification made use of the most reproducible landmark more appropriate for inclusion in this ratio.

These findings suggest that there may be an actual difference in the transverse dimension, or taper, of the mandible between Class I and Class II populations. Use of lingula, which fell just outside the level of significance with P=.06, and the alveolar ridge at the first molar, in combination with the mandibular canine apex can be used to create an AP width ratio. These ratios both demonstrated a statistically significant difference from the Class I population with smaller ratios indicative of mandibular anterior narrowing.

VI. CONCLUSION

Significant changes with treatment in the width of the mandible either skeletally or dentally are often viewed with much skepticism from the orthodontic and surgical communities. Indeed, there are definite limitations to corrections in this dimension and jaw. With this in mind, little focus has been placed on assessing the lateral excesses and deficiencies radiographically. As the lateral ceph gained popularity in use during the second half of the last century for diagnosis and treatment planning, the PA ceph, if taken at all, was often looked at mainly for asymmetrical surgical cases. However, critical and objective assessment of any dimension should proceed the methods for correction. Hopefully the introduction of CBCT into orthodontics around 10 years ago will ultimately provide the platform to better understand and evaluate the craniofacial complex in all dimensions so that treatment may follow accordingly.

Improved surgical techniques may yet allow increased manipulation of the mandible in treatment. While orthodontic limitations (ie. intercanine and alveolar bone width) seem to have been reinforced with the passage of time and extensive research, surgical considerations have been adjusted continually through the years with the introduction of new and varying orthognathic procedures including distraction to the midface and mandible. Utilizing an AP width ratio would potentially allow the clinician to analyze prior to treating the mandible at the point of deficiency. Antegonial notch would no longer be the sole point of reference when evaluating the width of the mandible.

The results of the study demonstrated that there is a statistically significant difference between canine root apices in Class I and Class II patients. The Class II group had a mean intercanine distance 2.2 mm less than their Class I counterparts. While no significant differences were found between the two groups in either of the posterior landmarks analyzed, the ratios generated indicated significant differences between Class I and Class II groups regardless of the posterior landmark used. This would indicate that there may well be an increased in taper for the Class II hypoplastic mandible when compared with a Class I normal population.

There were conflicting data, however, with mental foramen and the alveolar ridge at the canine failing to demonstrate significant differences between groups. Without collaboration of an anterior constriction in Class II patients from the alternate landmarks, the intercanine distance must be viewed with suspicion. Future research may help to identify additional landmarks in the anterior and posterior mandible with which to analyze its transverse dimensions. This could support or refute the conclusion that there is a difference in the transverse dimensions of Class I and Class II patients with mandibular AP hypoplasia.

The AP width ratios that demonstrated a greater constriction in the anterior mandible can be useful however. Further subdividing Class II patients between Div I and Div II might demonstrate a more significant

Further investigation may yield additional points with which transverse ratios could be established. Reliable anterior skeletal landmarks should be more indicative of the taper of the mandible itself and thus would be of interest in future studies.

Identification of these landmarks may improve with future improvements in the imaging technique or machines. The high spatial resolution offered by CBCT is offset by the low contrast resolution. This may make the image extremely accurate dimensionally but present problems in areas of similar density in close approximation.

Appendix A: CI I Pilot Study (Seven Landmarks, n=20), Raw Data

MAN 1-01		Time 1	Time 2	Time 3	SD	Mean
	MF-MF	48.7	48.8	48.4	0.208167	48.63333
	CA-CA	24.9	23.3	22.3	1.311488	23.5
	AvRCA	32.3	30.8	30.4	1.001665	31.16667
	AN-AN	75.8	77	76.1	0.6245	76.3
	L-L	76.6	78	78.5	0.984886	77.7
	AvRM	53.9	54.1	53.9	0.11547	53.96667
	Man6-6	43.3	42.5	43.4	0.493288	43.06667
MAN 1-02						
	MF-MF	48	47.9	45.5	1.415392	47.13333
	CA-CA	14.6	13.4	13.4	0.69282	13.8
	AvRCA	27.2	20.1	19.8	4.188476	22.36667
	AN-AN	82.4	75.5	74.4	4.336281	77.43333
	L-L	78.1	75.7	72.8	2.653928	75.53333
	AvRM	51.3	51.7	50.8	0.450925	51.26667
	Man6-6	41.5	40	40.2	0.814453	40.56667
MAN 1-03						
	MF-MF	49.7	47.9	49.6	1.011599	49.06667
	CA-CA	22.3	21.4	21.7	0.458258	21.8
	AvRCA	34.3	29.7	28.3	3.139002	30.76667
	AN-AN	88.5	86.8	89	1.153256	88.1
	L-L	84.2	86.4	84.2	1.270171	84.93333
	AvRM	56.2	57	56.4	0.416333	56.53333
	Man6-6	43.4	42.3	41.5	0.953939	42.4
MAN 1-04						
	MF-MF	50.1	50.7	50.7	0.34641	50.5
	CA-CA	18.7	16.9	16.9	1.03923	17.5
	AvRCA	33.3	30.4	29.7	1.908752	31.13333
	AN-AN	82.9	88.5	85.4	2.805352	85.6
	L-L	75.1	75.6	75.2	0.264575	75.3
	AvRM	54.4	54.2	53.1	0.7	53.9
	Man6-6	41.8	42.3	41.5	0.404145	41.86667

MAN 1-05						
	MF-MF	47.2	49.3	48.4	1.053565	48.3
	CA-CA	23.5	22.7	23.6	0.493288	23.26667
	AvRCA	31.8	31.7	31.5	0.152753	31.66667
	AN-AN	83.9	85.8	84.6	0.960902	84.76667
	L-L	79.6	79	79.6	0.34641	79.4
	AvRM	55.9	55.4	55.3	0.321455	55.53333
	Man6-6	45.3	46.6	45.2	0.781025	45.7
MAN 1-06						
	MF-MF	47	46.3	48.4	1.069268	47.23333
	CA-CA	16.3	15.9	17.3	0.72111	16.5
	AvRCA	27.1	27.4	25.9	0.793725	26.8
	AN-AN	82.9	82.6	81.7	0.6245	82.4
	L-L	84.6	82.4	82.1	1.36504	83.03333
	AvRM	54.6	54.3	54.1	0.251661	54.33333
	Man6-6	44.2	44.3	44.5	0.152753	44.33333
MAN 1-07						
	MF-MF	46.1	46.7	47.3	0.6	46.7
	CA-CA	23	22.7	23.3	0.3	23
	AvRCA	35.3	35.3	32.8	1.443376	34.46667
	AN-AN	90.7	87.2	87.7	1.892969	88.53333
	L-L	81.3	82.6	81.7	0.665833	81.86667
	AvRM	60.7	58.6	59.5	1.053565	59.6
	Man6-6	46	46.1	45.9	0.1	46
Man-08						
	MF-MF	42.6	42.4	42.1	0.251661	42.36667
	CA-CA	18	17.4	17.9	0.321455	17.76667
	AvRCA	28.6	27.3	29.1	0.929157	28.33333
	AN-AN	78.2	77.8	78.3	0.264575	78.1
	L-L	78.5	78.9	78.9	0.23094	78.76667
	AvRM	46.3	45.7	46.4	0.378594	46.13333
	Man6-6	34.2	34.8	33.7	0.550757	34.23333
Man	MF-MF	45	43.5	43.5	0.866025	44

1-09						
	CA-CA	18.5	18	19.1	0.550757	18.53333
	AvRCA	24.1	24.7	24.2	0.321455	24.33333
	AN-AN	71.5	70.9	69.3	1.137248	70.56667
	L-L	72.8	72.5	72.3	0.251661	72.53333
	AvRM	50.3	49.8	49.4	0.450925	49.83333
	Man6-6	36.4	38.4	37	1.02632	37.26667
Man-10	MF-MF	46.7	45.5	45.7	0.64291	45.96667
	CA-CA	21.4	22.3	21.3	0.550757	21.66667
	AvRCA	29	27.6	27.2	0.945163	27.93333
	AN-AN	80.5	78.8	79.8	0.8544	79.7
	L-L	76.2	75.5	75.8	0.351188	75.83333
	AvRM	53.7	54.1	53.2	0.450925	53.66667
	Man6-6	41.3	42.1	41.5	0.416333	41.63333
Man-11	MF-MF	45.7	46.1	46.3	0.305505	46.03333
	CA-CA	24.8	27.2	26.3	1.212436	26.1
	AvRCA	32.8	32.2	31	0.916515	32
	AN-AN	89.8	87	86	1.969772	87.6
	L-L	80.6	82.4	80.3	1.135782	81.1
	AvRM	55.9	55.9	54.8	0.635085	55.53333
	Man6-6	46.5	44.2	44.6	1.228821	45.1
Man-12	MF-MF	45.7	47.2	44.5	1.352775	45.8
	CA-CA	22	22.8	22.2	0.416333	22.33333
	AvRCA	28.3	27.3	28.5	0.64291	28.03333
	AN-AN	84.3	82.4	77.6	3.453018	81.43333
	L-L	81.8	78.2	77.4	2.343786	79.13333
	AvRM	50.8	51.6	50.8	0.46188	51.06667
	Man6-6	41.8	41.3	41.3	0.288675	41.46667
Man-13	MF-MF	44.7	43	44.1	0.862168	43.93333
	CA-CA	17.4	17.8	17.6	0.2	17.6

	AvRCA	27.2	27.6	27.7	0.264575	27.5
	AN-AN	82.6	83.9	82.9	0.680686	83.13333
	L-L	74.6	77	75.9	1.201388	75.83333
	AvRM	51.4	50.1	50	0.781025	50.5
	Man6-6	39.3	37.2	38.2	1.050397	38.23333
Man-14	MF-MF	44	42.9	42.4	0.818535	43.1
	CA-CA	22.9	21.6	21.4	0.814453	21.96667
	AvRCA	30.1	30.3	29.9	0.2	30.1
	AN-AN	80.6	75.8	78.4	2.402776	78.26667
	L-L	81.5	81.3	80.9	0.305505	81.23333
	AvRM	55.3	54.8	54.8	0.288675	54.96667
	Man6-6	43.3	43.7	44.2	0.450925	43.73333
Man-15	MF-MF	49.3	49	48.4	0.458258	48.9
	CA-CA	19.7	17.8	17.2	1.305118	18.23333
	AvRCA	26.8	27.3	26.8	0.288675	26.96667
	AN-AN	80.1	78.5	81	1.266228	79.86667
	L-L	77.7	76.9	76.7	0.52915	77.1
	AvRM	50.4	50.8	50.6	0.2	50.6
	Man6-6	38.7	39.4	39.3	0.378594	39.13333
Man-16	MF-MF	45	45.5	45.9	0.450925	45.46667
	CA-CA	22.1	21.2	22.1	0.519615	21.8
	AvRCA	30.1	29.9	29.9	0.11547	29.96667
	AN-AN	77.8	80.6	77.3	1.778576	78.56667
	L-L	78	77.3	76.7	0.650641	77.33333
	AvRM	51.7	50.7	51.1	0.503322	51.16667
	Man6-6	39.2	37.9	39	0.7	38.7
Man-17	MF-MF	47.6	46.6	46.5	0.608276	46.9
	CA-CA	22.5	20.1	19.8	1.479865	20.8
	AvRCA	27.5	27.5	27.5	0	27.5
	AN-AN	80.9	78.3	77.5	1.777639	78.9

	L-L	79.7	79.8	80.1	0.208167	79.86667
	AvRM	54	52.7	53	0.680686	53.23333
	Man6-6	42.2	41.6	41.4	0.416333	41.73333
Man-18	MF-MF	40.1	41.5	40.9	0.702377	40.83333
	CA-CA	23.3	21.5	21.1	1.171893	21.96667
	AvRCA	30.4	29.9	30.2	0.251661	30.16667
	AN-AN	84.1	87.8	86.3	1.861003	86.06667
	L-L	81	82.2	81	0.69282	81.4
	AvRM	52.1	52.2	52.1	0.057735	52.13333
	Man6-6	43.5	43.1	43	0.264575	43.2
Man-19	MF-MF	45.2	45.3	44.6	0.378594	45.03333
	CA-CA	17.4	17.1	17.6	0.251661	17.36667
	AvRCA	29.5	29.5	29.7	0.11547	29.56667
	AN-AN	78.5	78	77.6	0.450925	78.03333
	L-L	76.3	76.5	76.3	0.11547	76.36667
	AvRM	51.4	51.7	51	0.351188	51.36667
	Man6-6	41	40.4	40.6	0.305505	40.66667
Man-20	MF-MF	44.3	42.9	43.4	0.70946	43.53333
	CA-CA	21.4	20	20	0.80829	20.46667
	AvRCA	28.3	28.5	28.3	0.11547	28.36667
	AN-AN	81.5	74.2	69.1	6.232442	74.93333
	L-L	73.5	71.2	71.2	1.327906	71.96667
	AvRM	48.5	48	48.5	0.288675	48.33333
	Man6-6	37.2	37.7	37.4	0.251661	37.43333

Appendix B: CI I Results (Four Landmarks, n=50), Raw Data

MAN 1-01		Time 1	Time 2	Time 3	SD	Mean
	MF-MF	48.7	48.8	48.4	0.208167	48.63333
	CA-CA	24.9	23.3	22.3	1.311488	23.5

	AvRCA	32.3	30.8	30.4	1.001665	31.16667
	AN-AN	75.8	77	76.1	0.6245	76.3
	L-L	76.6	78	78.5	0.984886	77.7
	AvRM	53.9	54.1	53.9	0.11547	53.96667
	Man6-6	43.3	42.5	43.4	0.493288	43.06667
MAN 1-02						
	MF-MF	48	47.9	45.5	1.415392	47.13333
	CA-CA	14.6	13.4	13.4	0.69282	13.8
	AvRCA	27.2	20.1	19.8	4.188476	22.36667
	AN-AN	82.4	75.5	74.4	4.336281	77.43333
	L-L	78.1	75.7	72.8	2.653928	75.53333
	AvRM	51.3	51.7	50.8	0.450925	51.26667
	Man6-6	41.5	40	40.2	0.814453	40.56667
MAN 1-03						
	MF-MF	49.7	47.9	49.6	1.011599	49.06667
	CA-CA	22.3	21.4	21.7	0.458258	21.8
	AvRCA	34.3	29.7	28.3	3.139002	30.76667
	AN-AN	88.5	86.8	89	1.153256	88.1
	L-L	84.2	86.4	84.2	1.270171	84.93333
	AvRM	56.2	57	56.4	0.416333	56.53333
	Man6-6	43.4	42.3	41.5	0.953939	42.4
MAN 1-04						
	MF-MF	50.1	50.7	50.7	0.34641	50.5
	CA-CA	18.7	16.9	16.9	1.03923	17.5
	AvRCA	33.3	30.4	29.7	1.908752	31.13333
	AN-AN	82.9	88.5	85.4	2.805352	85.6
	L-L	75.1	75.6	75.2	0.264575	75.3
	AvRM	54.4	54.2	53.1	0.7	53.9
	Man6-6	41.8	42.3	41.5	0.404145	41.86667
MAN 1-05						
	MF-MF	47.2	49.3	48.4	1.053565	48.3
	CA-CA	23.5	22.7	23.6	0.493288	23.26667
	AvRCA	31.8	31.7	31.5	0.152753	31.66667
	AN-AN	83.9	85.8	84.6	0.960902	84.76667
	L-L	79.6	79	79.6	0.34641	79.4
	AvRM	55.9	55.4	55.3	0.321455	55.53333
	Man6-6	45.3	46.6	45.2	0.781025	45.7

MAN 1-06						
	MF-MF	47	46.3	48.4	1.069268	47.23333
	CA-CA	16.3	15.9	17.3	0.72111	16.5
	AvRCA	27.1	27.4	25.9	0.793725	26.8
	AN-AN	82.9	82.6	81.7	0.6245	82.4
	L-L	84.6	82.4	82.1	1.36504	83.03333
	AvRM	54.6	54.3	54.1	0.251661	54.33333
	Man6-6	44.2	44.3	44.5	0.152753	44.33333
MAN 1-07						
	MF-MF	46.1	46.7	47.3	0.6	46.7
	CA-CA	23	22.7	23.3	0.3	23
	AvRCA	35.3	35.3	32.8	1.443376	34.46667
	AN-AN	90.7	87.2	87.7	1.892969	88.53333
	L-L	81.3	82.6	81.7	0.665833	81.86667
	AvRM	60.7	58.6	59.5	1.053565	59.6
	Man6-6	46	46.1	45.9	0.1	46
Man-08						
	MF-MF	42.6	42.4	42.1	0.251661	42.36667
	CA-CA	18	17.4	17.9	0.321455	17.76667
	AvRCA	28.6	27.3	29.1	0.929157	28.33333
	AN-AN	78.2	77.8	78.3	0.264575	78.1
	L-L	78.5	78.9	78.9	0.23094	78.76667
	AvRM	46.3	45.7	46.4	0.378594	46.13333
	Man6-6	34.2	34.8	33.7	0.550757	34.23333
Man 1-09	MF-MF	45	43.5	43.5	0.866025	44
	CA-CA	18.5	18	19.1	0.550757	18.53333
	AvRCA	24.1	24.7	24.2	0.321455	24.33333
	AN-AN	71.5	70.9	69.3	1.137248	70.56667
	L-L	72.8	72.5	72.3	0.251661	72.53333
	AvRM	50.3	49.8	49.4	0.450925	49.83333
	Man6-6	36.4	38.4	37	1.02632	37.26667
Man-10	MF-MF	46.7	45.5	45.7	0.64291	45.96667
	CA-CA	21.4	22.3	21.3	0.550757	21.66667
	AvRCA	29	27.6	27.2	0.945163	27.93333

	AN-AN	80.5	78.8	79.8	0.8544	79.7
	L-L	76.2	75.5	75.8	0.351188	75.83333
	AvRM	53.7	54.1	53.2	0.450925	53.66667
	Man6-6	41.3	42.1	41.5	0.416333	41.63333
Man-11	MF-MF	45.7	46.1	46.3	0.305505	46.03333
	CA-CA	24.8	27.2	26.3	1.212436	26.1
	AvRCA	32.8	32.2	31	0.916515	32
	AN-AN	89.8	87	86	1.969772	87.6
	L-L	80.6	82.4	80.3	1.135782	81.1
	AvRM	55.9	55.9	54.8	0.635085	55.53333
	Man6-6	46.5	44.2	44.6	1.228821	45.1
Man-12	MF-MF	45.7	47.2	44.5	1.352775	45.8
	CA-CA	22	22.8	22.2	0.416333	22.33333
	AvRCA	28.3	27.3	28.5	0.64291	28.03333
	AN-AN	84.3	82.4	77.6	3.453018	81.43333
	L-L	81.8	78.2	77.4	2.343786	79.13333
	AvRM	50.8	51.6	50.8	0.46188	51.06667
	Man6-6	41.8	41.3	41.3	0.288675	41.46667
Man-13	MF-MF	44.7	43	44.1	0.862168	43.93333
	CA-CA	17.4	17.8	17.6	0.2	17.6
	AvRCA	27.2	27.6	27.7	0.264575	27.5
	AN-AN	82.6	83.9	82.9	0.680686	83.13333
	L-L	74.6	77	75.9	1.201388	75.83333
	AvRM	51.4	50.1	50	0.781025	50.5
	Man6-6	39.3	37.2	38.2	1.050397	38.23333
Man-14	MF-MF	44	42.9	42.4	0.818535	43.1
	CA-CA	22.9	21.6	21.4	0.814453	21.96667
	AvRCA	30.1	30.3	29.9	0.2	30.1
	AN-AN	80.6	75.8	78.4	2.402776	78.26667
	L-L	81.5	81.3	80.9	0.305505	81.23333
	AvRM	55.3	54.8	54.8	0.288675	54.96667
	Man6-6	43.3	43.7	44.2	0.450925	43.73333

Man-15	MF-MF	49.3	49	48.4	0.458258	48.9
	CA-CA	19.7	17.8	17.2	1.305118	18.23333
	AvRCA	26.8	27.3	26.8	0.288675	26.96667
	AN-AN	80.1	78.5	81	1.266228	79.86667
	L-L	77.7	76.9	76.7	0.52915	77.1
	AvRM	50.4	50.8	50.6	0.2	50.6
	Man6-6	38.7	39.4	39.3	0.378594	39.13333
Man-16	MF-MF	45	45.5	45.9	0.450925	45.46667
	CA-CA	22.1	21.2	22.1	0.519615	21.8
	AvRCA	30.1	29.9	29.9	0.11547	29.96667
	AN-AN	77.8	80.6	77.3	1.778576	78.56667
	L-L	78	77.3	76.7	0.650641	77.33333
	AvRM	51.7	50.7	51.1	0.503322	51.16667
	Man6-6	39.2	37.9	39	0.7	38.7
Man-17	MF-MF	47.6	46.6	46.5	0.608276	46.9
	CA-CA	22.5	20.1	19.8	1.479865	20.8
	AvRCA	27.5	27.5	27.5	0	27.5
	AN-AN	80.9	78.3	77.5	1.777639	78.9
	L-L	79.7	79.8	80.1	0.208167	79.86667
	AvRM	54	52.7	53	0.680686	53.23333
	Man6-6	42.2	41.6	41.4	0.416333	41.73333
Man-18	MF-MF	40.1	41.5	40.9	0.702377	40.83333
	CA-CA	23.3	21.5	21.1	1.171893	21.96667
	AvRCA	30.4	29.9	30.2	0.251661	30.16667
	AN-AN	84.1	87.8	86.3	1.861003	86.06667
	L-L	81	82.2	81	0.69282	81.4
	AvRM	52.1	52.2	52.1	0.057735	52.13333
	Man6-6	43.5	43.1	43	0.264575	43.2
Man-19	MF-MF	45.2	45.3	44.6	0.378594	45.03333
	CA-CA	17.4	17.1	17.6	0.251661	17.36667
	AvRCA	29.5	29.5	29.7	0.11547	29.56667
	AN-AN	78.5	78	77.6	0.450925	78.03333

	L-L	76.3	76.5	76.3	0.11547	76.36667
	AvRM	51.4	51.7	51	0.351188	51.36667
	Man6-6	41	40.4	40.6	0.305505	40.66667
Man-20	MF-MF	44.3	42.9	43.4	0.70946	43.53333
	CA-CA	21.4	20	20	0.80829	20.46667
	AvRCA	28.3	28.5	28.3	0.11547	28.36667
	AN-AN	81.5	74.2	69.1	6.232442	74.93333
	L-L	73.5	71.2	71.2	1.327906	71.96667
	AvRM	48.5	48	48.5	0.288675	48.33333
	Man6-6	37.2	37.7	37.4	0.251661	37.43333
Man - 21	MF-MF	50.7	50.1	52.1		50.96667
	CA-CA	20.5	20.1	19.6		20.06667
	L-L	80.5	80.7	81.2		80.8
	AVRM	54.4	53.7	53.9		54
Man-22	MF-MF	49.7	50.1	48.8		49.53333
	CA-CA	18.7	18.1	18.9		18.56667
	L-L	85.4	85.6	85.8		85.6
	AVRM	54.5	53.7	53.7		53.96667
Man-23	MF-MF	48	49.6	49.3		48.96667
	CA-CA	22.8	23.3	22.9		23
	L-L	79.6	79	79.6		79.4
	AVRM	56.3	54.5	55.2		55.33333
Man-24	MF-MF	46	46.5	46.2		46.23333
	CA-CA	21.1	20.2	20.9		20.73333
	L-L	81.8	82.5	82		82.1
	AVRM	52.5	52.3	53		52.6
Man-25	MF-MF	45.1	45	46.7		45.6
	CA-CA	24	24.1	23.8		23.96667
	L-L	84	83.5	83.7		83.73333

	AVRM	54.8	54.2	54.1		54.36667
Man-26	MF-MF	43.1	44.2	43.5		43.6
	CA-CA	19.5	18.2	19.3		19
	L-L	67.2	67.9	67.5		67.53333
	AVRM	49.9	49.1	49.3		49.43333
Man-27	MF-MF	48.9	48.2	48.6		48.56667
	CA-CA	22.9	22.6	21.1		22.2
	L-L	80.2	80.1	80		80.1
	AVRM	54.5	55	54.3		54.6
Man-28	MF-MF	52.6	55	53.5		53.7
	CA-CA	15.4	15.6	14.8		15.26667
	L-L	88	88.2	88.5		88.23333
	AVRM	52.8	53.7	53		53.16667
Man-29	MF-MF	51	51.5	51.9		51.46667
	CA-CA	18.1	18	18.9		18.33333
	L-L	83	82.3	82.7		82.66667
	AVRM	55.4	55.7	54.6		55.23333
Man-30	MF-MF	42.4	44.2	43.5		43.36667
	CA-CA	20.4	19.3	19.5		19.73333
	L-L	74.5	73.8	74.3		74.2
	AVRM	49.8	49.1	49.5		49.46667
Man-31	MF-MF	44.2	44.3	38.9		42.46667
	CA-CA	15.3	14.8	19.4		16.5
	L-L	83	82.1	84.6		83.23333
	AVRM	54.5	56.1	54.9		55.16667
Man-32	MF-MF	43.5	45	45.2		44.56667
	CA-CA	21	21.1	20.5		20.86667

	L-L	74.7	74.4	74.4		74.5
	AVRM	52.9	52.6	52.4		52.63333
Man-33	MF-MF	50.9	50.7	50.2		50.6
	CA-CA	23.7	24.3	23.9		23.96667
	L-L	85.8	85.9	85.8		85.83333
	AVRM	55.5	56	55		55.5
Man-34	MF-MF	43.3	45.7	46.6		45.2
	CA-CA	24.2	23.7	22.7		23.53333
	L-L	81.9	81.8	81.7		81.8
	AVRM	48.3	48.4	48.3		48.33333
Man-35	MF-MF	47.8	48.8	48.9		48.5
	CA-CA	18.9	18.9	18.9		18.9
	L-L	75.8	75.2	76.3		75.76667
	AVRM	50.3	50.4	49.9		50.2
Man-36	MF-MF	51	51.3	52.2		51.5
	CA-CA	24	24	22.1		23.36667
	L-L	81.3	82.9	81.8		82
	AVRM	53.3	51.3	52.6		52.4
Man-37	MF-MF	46.1	46.1	45.8		46
	CA-CA	17.3	17	17		17.1
	L-L	78.5	78.8	78.4		78.56667
	AVRM	47.8	47.5	47.4		47.56667
Man-38	MF-MF	43.6	44	44		43.86667
	CA-CA	20.2	19.2	19.5		19.63333
	L-L	71.6	70.9	71.4		71.3
	AVRM	50.9	50.5	50.9		50.76667
Man-39	MF-MF	46.1	45.6	44.5		45.4

	CA-CA	21.8	22.6	22.2		22.2
	L-L	74.6	74.6	74.8		74.66667
	AVRM	52.7	52.5	52.5		52.56667
Man-40	MF-MF	49.7	50.4	49.3		49.8
	CA-CA	19.8	19.4	19.6		19.6
	L-L	78.8	78.1	78.1		78.33333
	AVRM	53.1	53.1	52.9		53.03333
Man-41	MF-MF	43.3	43.5	44		43.6
	CA-CA	21.4	21.6	21.4		21.46667
	L-L	82.7	82.5	82.5		82.56667
	AVRM	54.3	53.7	53.9		53.96667
Man-42	MF-MF	50.2	50	50		50.06667
	CA-CA	24.6	24.8	24.8		24.73333
	L-L	79.7	79.5	79.5		79.56667
	AVRM	53.9	53.7	54.6		54.06667
Man-43	MF-MF	41.8	43.9	45		43.56667
	CA-CA	15.7	16.7	16.4		16.26667
	L-L	84	83.2	84		83.73333
	AVRM	52.3	52.3	51.9		52.16667
Man-44	MF-MF					
	CA-CA					
	L-L					
	AVRM					
Man-45	MF-MF	50.9	51.7	51		51.2
	CA-CA	17.7	17.1	18.2		17.66667
	L-L	80.9	81.3	81.4		81.2
	AVRM	52.9	52.9	53.1		52.96667
Man-	MF-MF	43.6	43.1	43.4		43.36667

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	CA-CA	18	18.2	18.5		18.23333
	L-L	67.6	67.9	68.3		67.93333
	AVRM	51.5	51	50.4		50.96667
Man-47	MF-MF	51.5	50.3	51.1		50.96667
	CA-CA	19.3	19.8	20.1		19.73333
	L-L	77.2	77.4	78		77.53333
	AVRM	53.2	53.6	53.8		53.53333
Man-48	MF-MF	50.5	51	51.1		50.86667
	CA-CA	18.5	19	19.2		18.9
	L-L	75.5	75.1	74.6		75.06667
	AVRM	52.6	52.6	52.1		52.43333
Man-49	MF-MF	46.5	46	46.7		46.4
	CA-CA	21.4	21.5	20.4		21.1
	L-L	75.8	75.3	76		75.7
	AVRM	53.9	53	52.5		53.13333
Man-50	MF-MF	45.1	45.2	44.9		45.06667
	CA-CA	21.2	20.1	20.5		20.6
	L-L	75.4	74.7	74.7		74.93333
	AVRM	53.8	54.2	54.2		54.06667

Appendix C: CI II Results (Four Landmarks, n=30), Raw Data

		Time 1	Time 2	Time 3	St Dev	Mean
Man2-01	MF-MF	47.5	47.7	46.7	0.52915	47.3
	CA-CA	19.4	19.2	19.4	0.11547	19.33333
	L-L	77.9	77.7	77.2	0.360555	77.6

	AvRM	48.9	49.1	49.1	0.11547	49.03333
Man2-02	MF-MF	47.8	46.3	46.3	0.866025	46.8
	CA-CA	17.9	18.8	19.1	0.6245	18.6
	L-L	83.5	82.9	83.8	0.458258	83.4
	AvRM	53.9	53.9	53.7	0.11547	53.83333
Man2-03	MF-MF	44.5	45.1	44.7	0.305505	44.76667
	CA-CA	18	17.8	17.7	0.152753	17.83333
	L-L	78.6	78.7	78.8	0.1	78.7
	AvRM	53	52.6	52.6	0.23094	52.73333
Man2-04	MF-MF	41.9	43.5	43.7	0.986577	43.03333
	CA-CA	16.2	16.1	16.1	0.057735	16.13333
	L-L	75.4	75.4	75	0.23094	75.26667
	AvRM	49.4	50.1	49.7	0.351188	49.73333
Man2-05	MF-MF	41.6	41.2	42.7	0.776745	41.83333
	CA-CA	15.7	15.7	16.5	0.46188	15.96667
	L-L	75.7	76.4	75.7	0.404145	75.93333
	AvRM	49.5	48.7	49.1	0.4	49.1
Man2-06	MF-MF	49.6	47.8	47.8	1.03923	48.4
	CA-CA	21.5	21.7	21.7	0.11547	21.63333
	L-L	74	73.8	74	0.11547	73.93333
	AvRM	50.4	50.8	50	0.4	50.4
Man2-07	MF-MF	41.6	42.5	40	1.266228	41.36667
	CA-CA	16.5	17	16.3	0.360555	16.6
	L-L	76.2	76.4	76.7	0.251661	76.43333
	AvRM	53.2	53.4	53.7	0.251661	53.43333
Man2-08	MF-MF	41.8	41.1	41.6	0.360555	41.5
	CA-CA	20.2	19.7	19.5	0.360555	19.8

	L-L	71.5	71.1	71.8	0.351188	71.46667
	AvRM	47.7	47.2	47.2	0.288675	47.36667
Man2-09	MF-MF	48.5	48.9	47.9	0.503322	48.43333
	CA-CA	18.8	19.1	18.6	0.251661	18.83333
	L-L	78.2	77.7	78.2	0.288675	78.03333
	AvRM	51.5	51.7	51.7	0.11547	51.63333
Man2-10	MF-MF	48.3	47	47.1	0.723418	47.46667
	CA-CA	16.7	16.6	16.2	0.264575	16.5
	L-L	73.3	73.1	73	0.152753	73.13333
	AvRM	51.7	51.5	52	0.251661	51.73333
Man2-11	MF-MF	48	47.2	47.4	0.416333	47.53333
	CA-CA	19.8	19.8	19.7	0.057735	19.76667
	L-L	75.3	75.1	75.7	0.305505	75.36667
	AvRM	55.1	54.4	54.1	0.51316	54.53333
Man2-12	MF-MF	49.7	49.8	48.1	0.953939	49.2
	CA-CA	16.7	16.9	17.4	0.360555	17
	L-L	74.6	73.9	74.4	0.360555	74.3
	AvRM	59	59	59.5	0.288675	59.16667
Man2-13	MF-MF	48	47.8	48	0.11547	47.93333
	CA-CA	15.1	15.5	14.7	0.4	15.1
	L-L	75.8	76.9	76.7	0.585947	76.46667
	AvRM	51.9	53	51.9	0.635085	52.26667
Man2-14	MF-MF	43.7	42.1	42.3	0.87178	42.7
	CA-CA	15.1	14.6	14.8	0.251661	14.83333
	L-L	73.5	73.1	72.8	0.351188	73.13333
	AvRM	51.7	51.7	51.9	0.11547	51.76667
Man2-15	MF-MF	45.4	45.3	45.4	0.057735	45.36667

	CA-CA	19.7	19.3	19	0.351188	19.33333
	L-L	75.7	75.3	74.9	0.4	75.3
	AvRM	50.7	50.7	50	0.404145	50.46667
Man2-16	MF-MF	49.8	48.6	48.4	0.757188	48.93333
	CA-CA	18.7	18.9	18.9	0.11547	18.83333
	L-L	85	85.7	85.3	0.351188	85.33333
	AvRM	55	54.7	54.5	0.251661	54.73333
Man2-17	MF-MF	47.4	46.9	46.6	0.404145	46.96667
	CA-CA	19.1	19	19.2	0.1	19.1
	L-L	72.9	72.1	72.3	0.416333	72.43333
	AvRM	49.6	49.3	49.4	0.152753	49.43333
Man2-18	MF-MF	42.2	42	43.9	1.044031	42.7
	CA-CA	16.8	16.6	16.1	0.360555	16.5
	L-L	73.5	72.6	73.1	0.450925	73.06667
	AvRM	50.8	50.9	51.1	0.152753	50.93333
Man2-19	MF-MF	46.3	45.2	47	0.907377	46.16667
	CA-CA	21.4	21.7	21.1	0.3	21.4
	L-L	78.6	78.9	78.9	0.173205	78.8
	AvRM	52.1	51.5	51.7	0.305505	51.76667
Man2-20	MF-MF	42.8	43.5	43	0.360555	43.1
	CA-CA	18.4	18.1	18.6	0.251661	18.36667
	L-L	84.1	83.6	83.8	0.251661	83.83333
	AvRM	47.6	47.6	47.6	0	47.6
Man2-21	MF-MF	44.4	44.5	46.2	1.011599	45.03333
	CA-CA	16	15.8	15.6	0.2	15.8
	L-L	73.5	73.7	73.5	0.11547	73.56667
	AvRM	47.5	47.7	47.3	0.2	47.5
Man2-	MF-MF	47.4	47.2	47	0.2	47.2

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	CA-CA	14.2	15.1	14.6	0.450925	14.63333
	L-L	79.7	79.7	79.1	0.34641	79.5
	AvRM	49.2	48.8	48.8	0.23094	48.93333
Man2-23	MF-MF	48.1	48.6	47.2	0.70946	47.96667
	CA-CA	20.6	20.6	20.2	0.23094	20.46667
	L-L	71.4	70.9	71.4	0.288675	71.23333
	AvRM	46.3	46.5	47.1	0.416333	46.63333
Man2-24	MF-MF	50	49.5	50	0.288675	49.83333
	CA-CA	14.5	15	14.7	0.251661	14.73333
	L-L	78.4	78.4	78.9	0.288675	78.56667
	AvRM	51.5	51.7	51.5	0.11547	51.56667
Man2-25	MF-MF	42	42.2	42.6	0.305505	42.26667
	CA-CA	18.2	18.6	18.2	0.23094	18.33333
	L-L	75.6	75.6	75.8	0.11547	75.66667
	AvRM	52.3	52.7	52.1	0.305505	52.36667
Man2-26	MF-MF	47.5	47.3	46.9	0.305505	47.23333
	CA-CA	23.3	22	22.8	0.655744	22.7
	L-L	79.4	79.4	78.9	0.288675	79.23333
	AvRM	52.8	53	52.6	0.2	52.8
Man2-27	MF-MF	47.2	46.6	44.1	1.644182	45.96667
	CA-CA	17.9	17.7	17.4	0.251661	17.66667
	L-L	74.7	75	74.6	0.208167	74.76667
	AvRM	54.3	54.5	53.4	0.585947	54.06667
Man2-28	MF-MF	47.8	48.5	46.9	0.802081	47.73333
	CA-CA	16.5	17.7	17	0.602771	17.06667
	L-L	80.4	80.6	81.1	0.360555	80.7
	AvRM	59.7	60.4	60.4	0.404145	60.16667

Man2-29	MF-MF	42.3	42.7	42.7	0.23094	42.56667
	CA-CA	16.2	17.2	16.2	0.57735	16.53333
	L-L	80.6	80.4	80.4	0.11547	80.46667
	AvRM	50.2	50.4	50.4	0.11547	50.33333
Man2-30	MF-MF	47.6	48	47.2	0.4	47.6
	CA-CA	21.1	21.3	20.6	0.360555	21
	L-L	79.6	79.4	79.4	0.11547	79.46667
	AvRM	55	54.7	55.2	0.251661	54.96667